A Circle Diagram for Optical Resonators

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A graphical representation of the relationships between the parameters of Hermite Gaussian light beams has been introduced recently[1,2] by S. A. Collins, Jr. T. Li has pointed out[3] that Collins' chart has two equivalent forms. Collins' chart relates the spot radius and phase front curvature at any position on the beam to the position and spot radius of the beam waist. In this note we point out that a similar chart can be made which relates the curvature parameters[4,5] of any two phase fronts along a Gaussian beam and the spot radii on those phase fronts. The curvature parameters are defined as $g_1 = 1 - d/R_1$, $g_2 = 1 - d/R_2$, where R_1 and R_2 are the radii of curvature of the phase fronts, and d is their separation. This new chart directly relates mirror curvatures and spot radii in a spherical mirror resonator.

The equations on which the chart is based are[5,6]

$$\frac{g_1}{g_2} = \frac{w_2^2}{w_1^2} \tag{1}$$

$$w_1 w_2 = \frac{\lambda d}{\pi} (1 - g_1 g_2)^{-\frac{1}{2}}, \tag{2}$$

where w_1 and w_2 are the spot radii on the two phase fronts. If we eliminate w_2 and g_2, respectively, from these two equations we get

$$\left(g_1 - \frac{1}{2g_2}\right)^2 + \left(\frac{\lambda d}{\pi w_1^2}\right)^2 = \left(\frac{1}{2g_2}\right)^2 \tag{3}$$

and

$$\left(\frac{\lambda d}{\pi w_1^2} - \frac{\pi w_2^2}{2\lambda d}\right)^2 + g_1^2 = \left(\frac{\pi w_2^2}{2\lambda d}\right)^2. \tag{4}$$

On a graph whose Cartesian coordinates are $\lambda d/\pi w_1^2$ and g_1, these two equations represent circles of diameters $1/g_2$ and $(\pi w_2^2/\lambda d)$, respectively, as shown in Fig. 1. The point of intersection of the two circles gives the values of w_1 and g_1 which satisfy both (3) and (4). A more complete chart, similar to Collins' chart, can be used to read off spot radii in a resonator whose mirror curvatures are known, or to find mirror curvatures from measurements of the beam spots. As does Collins' chart, this new chart has two equivalent forms, which in our case differ only in having the subscripts 1 and 2 interchanged.

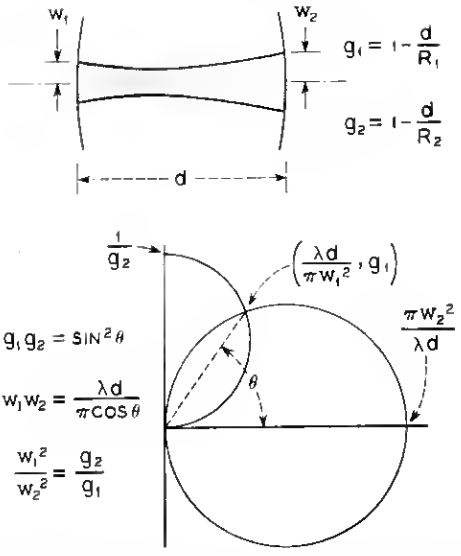

FIG. 1 — Circle diagram for spherical mirror resonators. Cartesian coordinates of the important points are indicated, along with some geometrical relationships.

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Gas Pumping in Continuously Operated Ion Lasers

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Gas ion lasers[1] operate at discharge currents of several amperes in small-bore tubing. Under these conditions the discharge acts to pump gas from the cathode to the anode[2] and pressure differences in excess of 10:1 can be established in less than one minute of discharge operation. Since the optimum pressure range for laser operation is narrowly defined relative to the range of pressures existing in the discharge tube (see Fig. 1), laser action usually deteriorates or goes out shortly after turn-on.